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ABSTRACT

Violent weather has always played an important part in human history. It is only in recent times that much of the underlying cause of weather has been understood. The discussion in this booklet considers time, space, and spirit. Time refers to a sense of history; space refers to geography; and spirit refers to life and thought. Several chapters related to the concepts of climate and meteorology, a time line related to the concepts, a map of the important geography related to the concepts a glossary of important terms, and a list of several study suggestions are included. (CW)

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Climate, Weather and People

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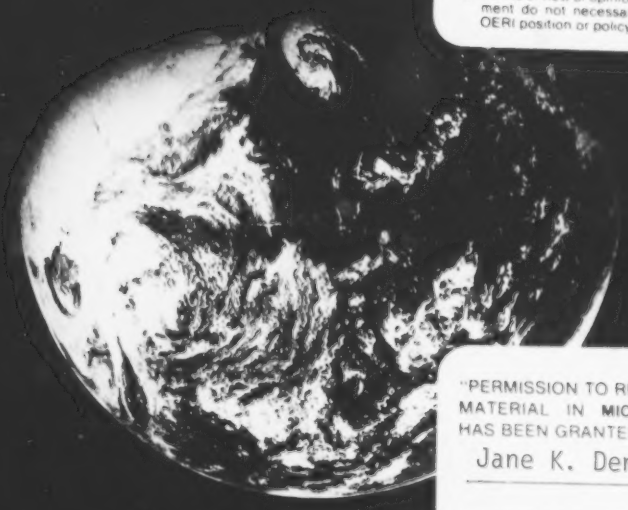

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A HAWKHILL LEARNING POWER BOOK

2

TIME, SPACE AND SPIRIT

KEYS TO SCIENTIFIC LITERACY

To the student,

This short book will help you understand our modern world. It has changed a lot since your parents were born. Even more since you were born. And it will change still more–much more–in your lifetime.

What is behind most of these big changes? Two things. Science and technology.

What can you do about it? The first step is to understand more about science and technology and how they connect with our world. Especially the ever-growing world of free democratic societies. One way to do this–the way this book follows–is to look at the world from three angles: *Time, Space* and *Spirit*.

Time means history. You can learn how science and technology have worked in the past and are working today.

Space means geography. You can learn where important things happened in the past and are happening today.

Spirit means life. The life of the mind. You can learn the key words, concepts and ideas that power science and technology (and society) today.

This book teaches about science, technology and society from all three of these angles–*Time, Space* and *Spirit*.

Read on.

This book belongs to:

Climate, Weather and People

Bill Stonebarger
Illustrations by Lin Haley

Hawkhill Associates
Madison, Wisconsin

This book is one of a series of sixteen Learning Power Books in the *Time, Space and Spirit–Keys to Scientific Literacy* series. It is designed to accompany the video program of the same name.

The *Time, Space and Spirit–Keys to Scientific Literacy* series was written and produced with consultation from the History of Science Department at the University of Wisconsin-Madison.

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an invasion

The largest overseas expedition force in history massed off the shore of South Korea in June of 1281. One hundred forty thousand Chinese, Korean and Mongol troops had been ordered by the Chinese emporer, Kublai Khan, to invade and conquer Japan.

helped by a kamikaze

They failed in their mission. And the reason they failed was a giant hurricane. The Japanese called it a "kamikaze," a divine wind that destroyed the invader's ships and drowned their warriors just as they reached the coast of Japan.

If it had not been for that divine wind, who knows how different the histories of China, Japan and Korea might have been.

the Spanish Armada

So too in the western world, when the famous Spanish Armada sailed into English waters, it was decimated by violent storms. Some historians

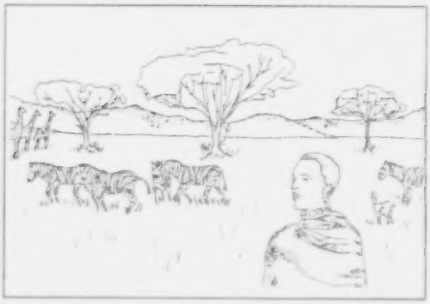
think that if it had not been for these storms of 1588 we might be a Spanish-speaking country today instead of an English-speaking one.

weather and climate

From time immemorial violent weather has played a dramatic and major role in human history. And ever since humans have been humans, normal weather, what we call climate, has set the stage and often written the script and directed the play for the human drama.

humans adapt

More than any other creature, human beings have managed to survive and prosper in climates that range from bitter Arctic cold to sunny tropic heat; from humid jungle to the dry desert; from prairie to mountain, from village to city. In modern times we have even managed to live in the climate under the ocean and out in space.



the causes of weather and climate

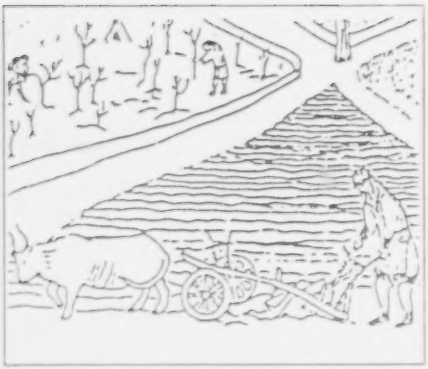
However it is only very recently in human history that we have come to understand very much about the underlying causes of weather and climate.

astrological theories

For most of past history people have believed astrological and supernatural theories to explain weather and climate. Just as good health or bad health was blamed on the gods, so was good weather and bad weather. Especially bad. Droughts, storms, floods, unusual spells of cold or hot weather were seen as coming from angry gods as punishment for human sins.

practical people

There were exceptions to this rule, however. On the practical side farmers and sailors did develop a weather sense. That is, their day-to-day experi-



ence gave them many common sense ideas about what to expect with weather.

"When a halo surrounds the moon, the month will bring rain."

"Red sky in the morning, sailors take warning. Red sky at night, sailor's delight."

not always reliable

These axioms were not always reliable, of course, but they were better than no axioms at all. And they did mark a step forward in thinking about weather and in trying to find natural causes for natural events.

first natural scientists

In addition to this folk wisdom, some of the world's first natural scientists in ancient Greece began to put together the first theoretical attempts to explain climate and weather. Instead of calling on the gods to explain how the world was put together and how it worked, men like Thales, Anaximander, Democritus, and Hippocrates searched for natural reasons to explain natural events.

Aristotle

One of these first scientists, Aristotle, wrote one of the most influential books about weather, "Meteorologica." In this book he brought together the best of ancient folk wisdom and rational thought.

astrology popular in Renaissance

Rational, astrological and religious theories about weather and climate existed side by side for many centuries after Aristotle. During the late Middle Ages and Renaissance, astrology in particular was very popular. In the sixteenth century, for instance, over three thousand different almanacs were printed in Europe, all claiming to predict the details of weather for the coming year, all based on astrological lore and all equally unreliable.

a sensational prediction

In 1499 a prediction of one Justus Stoffler for the month of February, 1524 created a great sensation. He pointed out that in that month the three planets, Mars, Jupiter and Saturn would all be in the constellation of Pisces. This was felt to be a sure sign of tremendous downpours. Learned arguments were held on how tremendous the downpours would be. Would it be a universal deluge as in the time of the flood and Noah's Ark in the Bible? Or just a very very rainy time?

below average rainfall

Many people left their homes and took refuge on hilltops during the fateful month. But alas, it turned out to be an ordinary month with slightly below average rainfall.

almanacs remain popular

Similar predictions were made many times in years following, as in years before. The fact that they were so often wide of the mark did not seem to make the public distrustful. And indeed today the farmer's almanacs and the astrological books still have strong sales.

meteorology needed foundations

Though Aristotle and the other ancient Greeks made a beginning in scientific meteorology, real progress in this science had to wait until other basic sciences like physics, chemistry, geology and astronomy laid more secure foundatiosns.

Pascal has an idea

Galileo invented the thermometer in 1600. One of his pupils, Evangelista Torricelli, invented the barometer forty years later. A few years after that a famous French scientist and mathematician, Blaise Pascal, carried out a remarkable experiment with one of the early barometers. He wanted to find out if air presssure changed with altitude. To find out, Pascal had his brother-in-law laboriously lug a barometer (early barometers were very heavy) to the top of the highest mountain in France, Mount Puy.

air is not the same everywhere

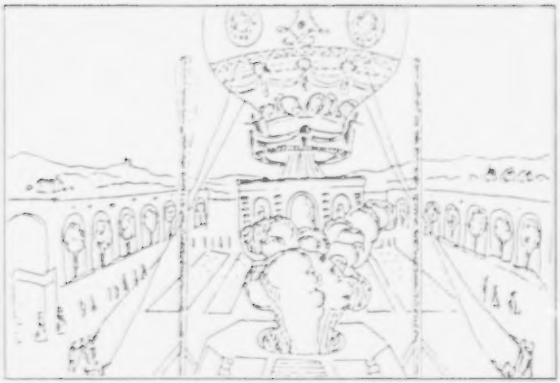
He found out that air pressure did change with altitude. Air was not the same everywhere. The invisible atmosphere itself has a structure, perhaps even a history!

Early chemists of the late eighteenth and early nineteenth centuries discovered the existence of gases like oxygen, carbon dioxide and nitrogen. Scientists could now put together a more accurate description of the mixture of gases that made up air.

Benjamin Franklin experiments

America's own Benjamin Franklin experimented with kites in a thunderstorm. He discovered that there was electricity in the clouds. (He was lucky he wasn't killed.)

In 1783 Franklin watched the world's first hot air balloon ascend from Versailles, France. It carried



aloft a sheep, a duck and a rooster. When a sceptic asked Franklin what good such a contraption might be, he is said to have replied, "Of what use is a newborn babe?"

balloons prove their worth

Balloons did prove their worth many times over in the following century. Men ascended to hitherto unimagined heights in the atmosphere. They carried with them thermometers, barometers and other scientific instruments, all designed to ferret out the mysteries of the atmosphere, earth's incredible membrane.

lead to modern rockets and weather satellites

Today, rockets and earth satellites give still more detailed data, tracking the jet stream, watching hurricanes develop and move, and measuring the solar energy coming to earth. Of course, the more data you get the more difficult it becomes to keep it all straight. How do you make sense of so many numbers?

the telegraph

A hundred fifty years ago an invention came along that helped. The telegraph. Invented by Samuel Morse in 1832, it was almost immediately seized on by meteorologists of the day to move weather data from place to place at the speed of light. With the data from vast areas up-to-date, the first weather maps could be made.

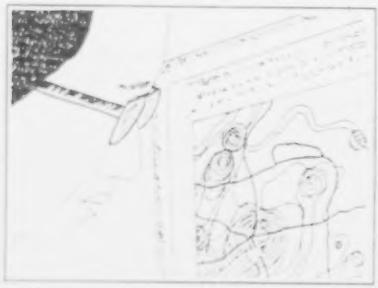
the first weather map

Here is what the first chart prepared in the United States in 1842 looked like. It used arrows of different lengths to represent the direction and speed of the wind. It used different colors to show where the weather was sunny, cloudy or rainy. With the aid of these new maps that could now be prepared every day, large-scale national weather patterns could be seen and forecasting became more reliable.

national weather service begins

National weather services were founded. Hurricanes and other big storms could be anticipated, and with warnings, property losses and human casualties could be reduced dramatically.

Weather maps and telegraphic communications in the nineteenth century were giant steps forward in weather understanding and prediction. Even bigger steps are being taken now in the late twentieth century, aided greatly by two new technologies–space satellites and the computer.



better forecasts

With the help of these two new technologies our modern-day weather experts can gather and intelligently put together weather data from all over the world. Using this data they can put together more reliable short- and long-range forecasts. Not perfect ones as we all know, but significantly better than in the past.

climate forecasts

If even today weather forecasts still leave us with more than a little uncertainty, climate forecasts are little better than educated wild guesses.

Climate refers to the long-term weather pattern of a region. How cold it usually gets. How warm. How wet. How windy.

Though there were isolated examples in the past, scientific study of climate changes has only begun to come of age in very recent years.

many changes in four billion years

A science of climate change had to wait until it was established that the earth has gone through many climate changes in past centuries. About the middle of the nineteenth century geologists were beginning to realize that the earth was much older than anyone had believed. Not a few thousand years old, nor even a few million–but over four billion years old.

continents float apart, ice ages come and go

In that long time span, the continents have floated from one spot to another on the earth's surface. The ice caps have formed and have melted and formed and melted again. Over much of the four

billion years the earth was a good deal warmer than it is now. However, over the past few million years it has mostly been colder than now.

wetter and dryer

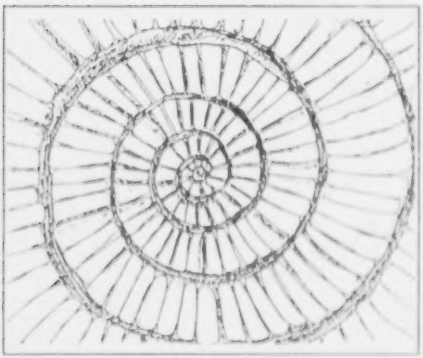
Along with hot and cold, the earth has always gone through wetter and dryer periods. And which parts of the globe are wet and which parts are dry has continually shifted.

Sahara Desert once a fertile garden

What is now the great Sahara Desert, for example, was once a fertile moist agricultural region. What is now a land of eternal ice near the North Pole was once a tropical forest. And so it goes. But on a very very long time scale.

tools of climatologists

These facts about our earth have been laboriously established by combining data from many sources. The fossil record in the rocks–nature's history book–for one. Also the record of pollen deposits in old lake beds. The record from ice cores in the polar regions. For more recent changes in climate, scientists use the evidence from tree rings, grape harvests and ships' weather logs. We are just beginning to sort out what this has meant in the past. And what it could mean for the future.



a new ice age?

Are we about to enter a new ice age? Some climatologists think so. Recent research has showed that earth seems to go through cycles of warming and cooling. Big ten-thousand-year cycles which give rise to major ice ages. But also much shorter three-hundred-year minor cycles. Three hundred years ago, for instance, our northern hemisphere was a few degrees colder on the average than it is

now. If this cycle repeats, it may be that early in the twenty-first century we will again go into a colder period.

will earth become warmer?

On the other hand, a more immediate concern to many climatologists today is how soon we will see changes in the earth's climate from what is called the *greenhouse effect*. Human activities, especially the burning of so many fossils fuels and the cutting down of tropical forests, are adding significant amounts of carbon dioxide to the atmosphere. This gas in turn reflects more heat back to earth instead of letting it escape into space. If the trend continues or accelerates, our climate will become warmer.

Let's look at some of these questions in more detail in the second part of this book.

five minutes to broadcast time

Five minutes to broadcast time. Mike Nelson, weather person for WKOW in Madison, Wisconsin is putting the final touches on his video weather map while talking by phone to a weather correspondent in northern Wisconsin. From the phone call, he is trying to get the latest on-the-spot news about a developing snowstorm that is headed south.

satellites keep watch

Twenty-two thousand three hundred miles away–out and away from planet earth–a small satellite keeps close watch on this same storm. Five hundred twenty-two miles out two more satellites pick up information about cloud cover, atmospheric temperatures, snow and ice boundaries and solar activity.

data relayed

Data from both of these satellite systems is continually relayed back to over one thousand ground

stations on earth. Central coordinating centers like the National Center for Atmospheric Research in Boulder, Colorado quickly decode and analyze the data with the help of the world's largest and fastest computers. They send the results in the form of weather maps and other weather information to station WKOW and thousands of other stations and terminals in the international weather network.

weather report and forecast

Right on time at 5:01 p.m. Mike is on camera giving the summarized results, what is happening and what will probably happen to the local and national weather pattern in the next twenty-four to forty-eight hours.

Mike also gives longer-range forecasts for the week, the month or even the season ahead. He cautions his viewers, however, that these longer-range forecasts are less reliable than the short-range ones.

climate forecasts much more difficult

What he does not often give is news about some really long-range history and forecasting of the weather, the kind we call climate changes and climate forecasting. He doesn't because the changes here are usually measured in decades, centuries or even millenia. And forecasts of these long range climate changes are even more unreliable!

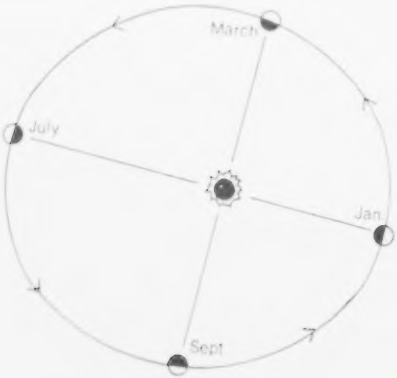
Let's look at some basics of what we know now and what we don't know about weather and climate.

planet earth

Our planet earth is spinning on its axis at high speed, turning completely around once every twenty-four hours.

revolving around the sun

It is revolving around a body of enormous energy output, our sun, making the complete turn once every 385 1/4 days.



earth's tilt causes seasons

Earth is tilted on its axis about 23 1/2 degrees so that at different times in its revolution around the sun some parts of the earth get more direct rays than others. This causes our seasons.

earth's skin

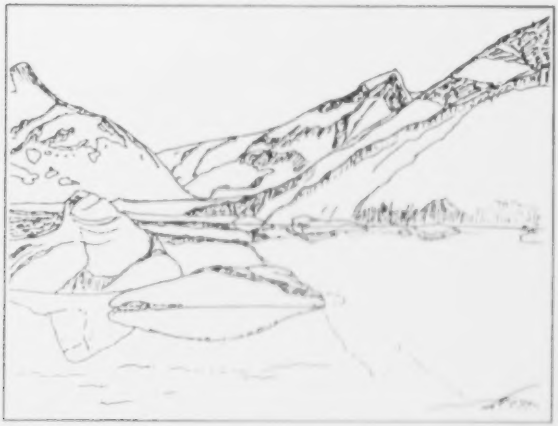
Earth has grown a transparent gaseous skin, our atmosphere. It is made of a mixture of gases. We call the mixture air. This air skin is, among other things, fluid. That is, it is in continual motion around the parent earth, bathing it, protecting it, nourishing it and keeping it comfortably air-conditioned.

earth's water

In doing these jobs, it gets a lot of help from another layer of surface fluid, earth's water. In fact if you were coming into earth from outer space for the first time, you would almost certainly think earth was a water planet, there is so much of it.

the solid earth

And finally there is the solid part of earth, the mountains, valleys, prairies and hills. The deserts, forests, grasslands and glaciers. All three of these–land, air and water–play big parts in determining weather and climate.



the power house

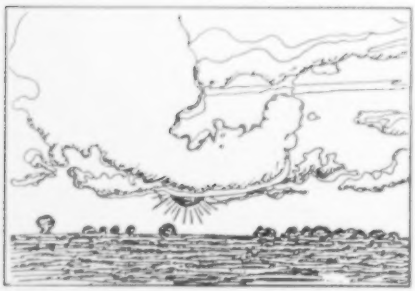
And finally, we almost forgot the most important part of all, the sun. For it is the sun that provides the engine to not only power all changes in weather and climate but to make it possible to have weather and climate at all.

Air, earth, water and fire–what the ancients called the four elements–each one constantly in change.

And the results–our weather. And if you take the average of a typical year's weather in any region, our climate.

energy output of sun

The most important of air, earth, water and fire is fire. Not literally fire as we know it on earth. Instead the "fire" of the nuclear furnace that is responsible for the energy of our sun. The energy output of the sun is also the most reliable and constant element in weather and climate. It used to be thought it was completely constant. Today we know this is not true. Sometimes the sun sends out more and sometimes less energy. The differences are comparatively small but the differences are important. Especially where long-range changes in climate are concerned.

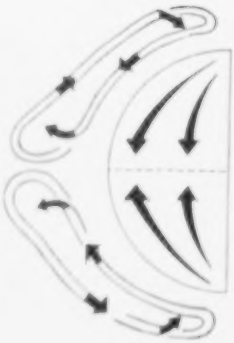


earth's tilt

Earth is constantly bathed in energy coming from the sun. The part of earth closest to the equator gets far more solar energy than the poles. Because of the earth's tilt, the portions of earth north and south of the equator are constantly changing in the amount of direct energy received. You can see already the complications building up, and we are only just beginning our weather-climate story.

winds blow

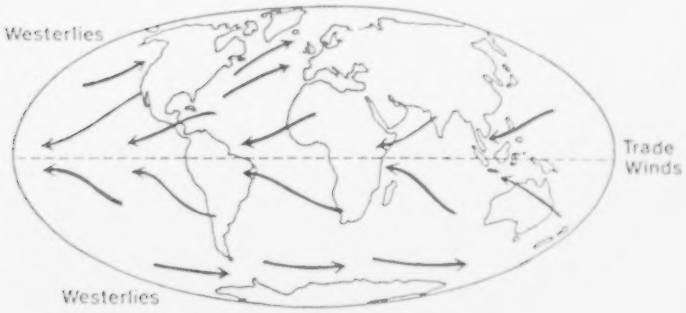
Because the equatorial regions get more energy than the north or south, this causes winds to blow and oceans to flow. Warm air, being lighter than cold air, rises. Conversely, cold air sinks. This creates a cycle of air flow where



warm air moves up and away from the equator and cold air moves down and toward the equator.

earth's motion changes winds flow

If earth were perfectly smooth like a billiard ball, and were standing still, you would have a circulation pattern easy to follow. As warm air moves toward the poles, cold air moves toward the equator and you have perfectly predictable constant winds.



trade winds and prevailing winds

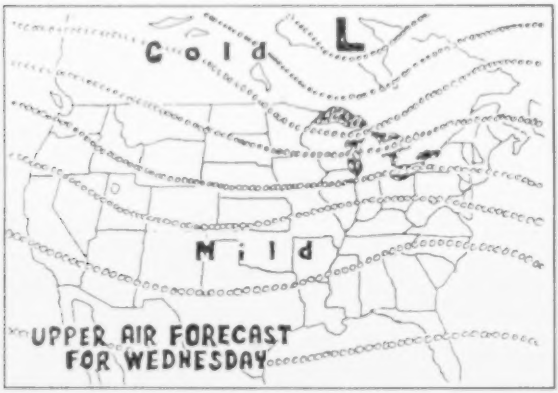
But earth is not smooth, nor is it standing still. We are constantly turning from east to west. The air is not attached to earth. It is free to slide over it. This causes the air near the equator to move in strong trade winds from east to west. While the air further north or further south tends to move from west to east in prevailing winds.

ocean currents and land masses

But that is not the whole story either. Ocean currents like the Gulf Stream, the Japanese current, El Nino and others are also very powerful energy transformers. They, too, influence the movement of heat from equator to poles, and hence strongly influence our weather and climate. So, too, the great land masses, as well as the ice masses in the far north and south, have strong effects on our weather and climate.

jet streams

To complicate matters further, the air masses close to the earth have different patterns from those higher out. Jet streams in the atmosphere have an especially strong influence on what goes on below.

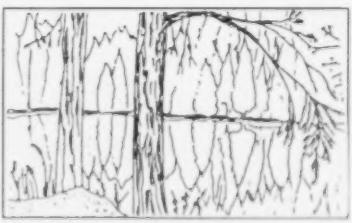


volcanoes

Volcanoes explode enormous amounts of dust and gas into the atmosphere which changes the earth's weather and climate world-wide.

different albedos

Different surfaces, too, have different *albedos*. This means they reflect more or less of the sun's radiant energy. Snow and ice, for instance, reflect 90 percent of the sun's energy back to space. On the other hand, forested land reflects only about 7 percent back to space.



The combination of all these currents, winds, albedos, volcanoes, tilts, jet streams and solar variations in output gives us weather and climate.

need for computers

You can see why even the most powerful computers have such an impossible job predicting the exact weather happenings for any given day, week or month.

NCAR

At NCAR, the National Center for Atmospheric Research, in Boulder, Colorado scientists are making progess in unravelling the mysteries. With help from some of the world's most powerful computers, meteorologists and climatologists at NCAR are building more and more sophisticated models of atmospheric behavior. They program these models into their supercomputers–able to make eighty million calculations a second–and see how close they can come to the actual atmospheric conditions of past, present and future.

climate predictions

One of the hottest areas of research and conflict today is predicting what will happen to our climate in the next few decades.

human activities

There are two major concerns. One is deciding what influence industrial, agricultural and forestry activity is having on the world's weather and climate.

natural cycles

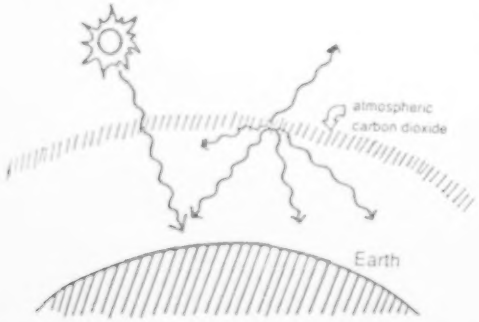
The second is deciding what influence long-range natural cycles of change have on the world's weather and climate.

too much carbon dioxide in atmosphere

As for human activities the biggest concern at present is the increasing amount of carbon dioxide in the atmosphere. One way it gets there is through burning more and more fossil fuels. Since forests take large amounts of carbon dioxide out of the air, replacing it with oxygen–cutting down more and more tropical forests will also alter the balance.

greenhouse effect

This increasing percentage of carbon dioxide in the air leads to what is called the *greenhouse effect.*



Here is what happens. Carbon dioxide reflects heat back to earth more than the other major gases in the air. So an increased percentage of carbon dioxide means an increased amount of heat on the earth's surface.

could melt ice caps

Too much extra heat could mean a significant melting of the ice caps at the north and south poles. This in turn will cause ocean levels to rise, flooding many coastal cities. It will also cause large changes in winds and rainfall patterns, which in turn could severely alter agricultural, economic and political events in the world.

another ice age?

The seriousness of the greenhouse effect is a subject of hot debate now among specialists and among citizens and politicians. The fact that we are heading for another ice age in the more distant future is generally agreed upon today by specialists in climate. The only question is how distant.

cycles of cold and warm

Back in the 1930s a Yugoslav astronomer named Milutin Milankovitch hit upon a relationship between small changes in the earth's orbit, small changes in the earth's tilt, small changes in the gravitational pull of the sun and moon on equatorial regions. He was able to relate these directly to the frequency and periodicity of ice ages of years

past. At first scientists were sceptical, but by now it is generally agreed he was right.

how soon?

In separate cycles of 19,000, 23,000, 41,000 and 100,000 years, the earth has been going into and out of deep freeze. At present we are in an interglacial period, but we can expect that another ice age will begin soon. How soon? We're not sure.

last major and last minor ice age

For a major ice age, according to Milankovitch's theory, *soon* will be five or six thousand years from now. However, in the meantime, we will probably enter a shorter cycle of colder weather in the next hundred years. We know that every three or four hundred years, earth has gone into a little ice age. Temperatures in these little ice ages averaged two to three degrees cooler. The last little ice age was in the 1600s.

only a few degrees

Two or three degrees may not seem like much but it can mean big differences on earth. It would almost certainly cause major changes, for instance, in rainfall patterns. The great agricultural belts of North America and Asia would become dryer, while other areas like India, western Asia and China would probably receive more rain.

Can we do much about weather and climate?

too many variables

There are so many variables in weather and climate that predicting it is very difficult. Trying to control weather and climate is even more difficult. Probably impossible for the foreseeable future. This is not only because there are so many variables. What is not often realized is the large amounts of energy involved in weather and climate.

a hurricane's energy

One hurricane, for example, is driven by energy over a thousand times as great as the total electrical power generated in the United States since electricity was invented. In twenty-four hours the average hurricane releases more energy than five hundred thousand atomic bombs of the Hiroshima size. And that is only about 3 percent of the energy remaining in the hurricane!

thunderstorms and tornados

Even a good sized thunderstorm far surpasses any human-initiated or controlled energy event. And for intensely concentrated energy, little in nature can approach the power of a tornado. Probably the best we can do with these major storms for the foreseeable future is develop better tracking and forecasting skills so that at least people can be warned and take measures to get out of the way.

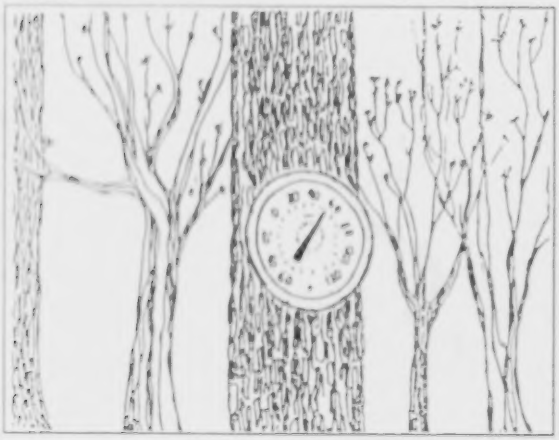
weather modification

Despite the difficulties, studies and experiments are proceeding with reasonable hopes for success on things like seeding rain clouds, seeding the eye of a hurricane in hopes of altering the direction of its sweep. Taking it out to sea, for instance, instead of seeing it devastate a coastal area.

weather-wise

Besides the practical side of weather, there is also the wonder side. And the fun side. For most of its history, the science of meteorology has been the domain of the amateur scientist. And still today there is a place for the nonprofessional. Many people, old and young, throughout the world, have joined in networks to explore the earth's largest and freest laboratory–the atmosphere we live in.

You can too.

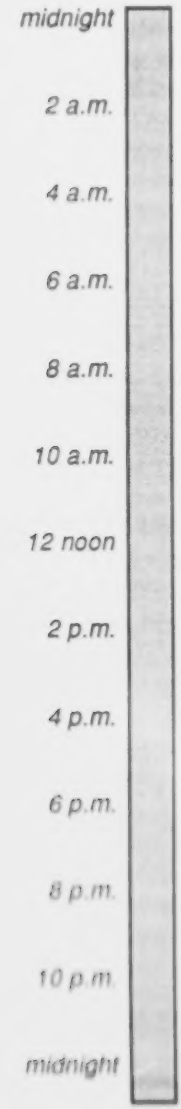


TIME ...

To understand the world of today it helps to know something about the world of yesterday. Kings and queens, wars and famines, presidents and paupers have all played a part. But more important than any of these in changing the past world into the world of today has been science and technology. The time line below will help you place important events and people in historical time.

EVENTS IN WORLD HISTORY		EVENTS IN SCIENCE & TECHNOLOGY
	1500	1500
		1500-1700 Age of Exploration: Columbus, Cortez, Cartier, Magellan, & others
1588 defeat of Spanish Armada by England		
	1600	1600
1616 death of Shakespeare		1593 Galileo invents thermometer
		1643 Torricelli invents barometer
		1648 Pascal discovers earth's atmosphere
1550-1850 little ice age: Europe and North America have colder climate than today	1700	1700
1776 American Revolution		
	1800	1800
		1783 first hot air balloons in France
		1832 Morse invents telegraph: first U.S. weather maps
1861-65 Civil War		1840s Louis Agassiz finds evidence of ice ages
	1900	1900
1914-18 World War I		1912 Wegener proposes theory of continental drift
1939-45 World War II		

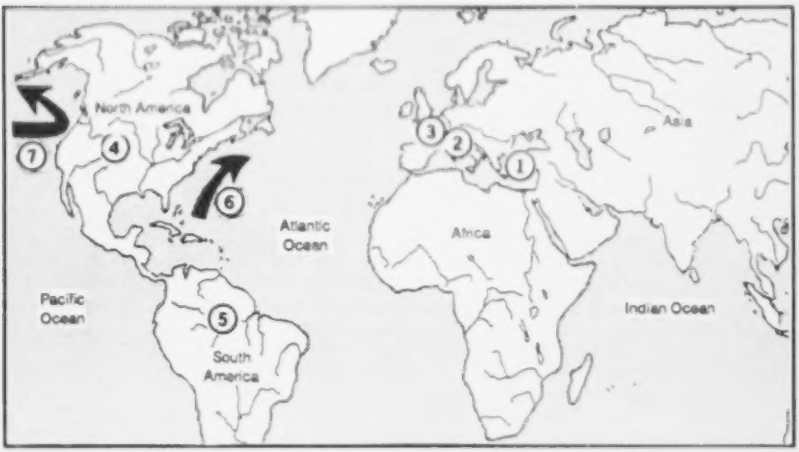
The time line below summarizes twenty-four thousand years of earth history. Imagine you are making a time-lapse movie in which one person's life zips by in four minutes. On this scale one thousand years go by every hour. The entire movie will take one 24-hour day to show. It begins at midnight.



midnight	**22,000 B.C.**	*Homo sapiens* becomes dominant on earth
2 a.m.		
4 a.m.	**18,000 B.C.**	maximum extent of last ice age: continental glaciers cover most of Europe and North America, extending as far south as the Ohio River
6 a.m.		
8 a.m.	**14,000 B.C.**	
10 a.m.		glaciers begin to retreat
12 noon	**10,000 B.C.**	evidence of people in North and South America
2 p.m.		
4 p.m.	**6,000 B.C.**	Great Lakes are formed and free of ice
6 p.m.		
8 p.m.	**2,000 B.C.**	agricultural civilizations in Asia, Africa, Europe, Middle East, North and South America
10 p.m.	**A.D. 1**	
midnight	**2,000**	little ice ages come and go every few hundred years

SPACE ...

There is a saying, "If you don't know where you are going, any road will get you there." One of the important parts of knowing where you are going is a knowledge of geography. The map below will help you to locate the important events and people discussed in this book.



1. Ionian Greece — Where the world's first scientist/philosophers lived and worked. Now a part of modern Turkey.

2. Italy — Center of the Renaissance where Galileo, Torricelli and other scientists lived and worked.

3. France — Where Pascal discovered earth's atmosphere and Franklin watched world's first hot air balloon.

4. Colorado — Site of NCAR, National Center for Atmospheric Research.

5. Brazil — World's largest rain forest. Now in danger from development.

6. Gulf Stream — Warm water current in Atlantic Ocean.

7. Japanese current — Warm water current in Pacific Ocean.

SPIRIT...

Time and space are meaningless without spirit. Spirit is the part in each of us that understands. The part that sees connections between words and things–connections that surprise and make sense. Study the key words, concepts and ideas below so that you can understand how time, space and spirit have worked in the past–and are working today.

albedo A measure of how much solar energy is reflected from a particular surface of earth. (p. 17)

astrology A pseudoscience that claims to be able to predict the future on the basis of planet and star positions. (p. 2, 4)

atmosphere The envelope of gases that surrounds the surface of the earth. (p. 5-6, 14)

axis An imaginary line through the earth from the North Pole to the South Pole around which the earth revolves once a day. (p. 13)

barometer An instrument to measure air pressure. (p. 5)

carbon dioxide A gas in the atmosphere made of two parts oxygen to one part of carbon. (p. 5, 10, 18-19)

climate Weather of a region when considered as a whole over an extended time period.

continental drift See *plate tectonics.*

equator An imaginary line around the earth equidistant from the poles. (p. 15)

fossil fuels Sources of energy like coal, oil and gas that were made in past ages from the decay of plants and animals. (p. 10, 18)

Franklin, Benjamin Famous American inventor, writer and political leader. (p. 5-6)

Galileo Famous Italian scientist (1564-1642) who discovered important laws of motion and pioneered a new way of thinking called science. (p. 5)

geology The science of the changing earth. (p. 5, 8)

glacier Large masses of snow and ice that do not melt in a single season. At one time continental glaciers covered most of northern North America and Europe. (p. 8-9, 19-20)

greenhouse effect A gradual warming of earth's climate caused by excessive carbon dioxide which reflects heat back to earth instead of letting it escape into space. (p. 10, 19)

hurricane An intense storm that begins over the ocean. Generates winds of over a hundred miles an hour and causes great destruction when it hits land areas. (p. 1, 21)

ice age There have been many ice ages in earth's past. The most recent ended about ten thousand years ago. (p. 8-9, 19-20)

jet stream A steady flow of air high in the atmosphere that has much influence on weather at the surface of earth. (p. 17)

meteorology The science of weather and climate.

NCAR The National Center for Atmospheric Research in Boulder, Colorado. (p. 12, 18)

Pascal, Blaise A French philosopher, mathematician and scientist (1623-62) who was one of the first to prove earth has an atmosphere. (p. 5)

plate tectonics A theory, sometimes called continental drift, that explains how large masses of land float on underlying molten rock. (p. 8-9)

solar energy Particles and waves of electromagnetic energy that come from our sun to earth. Responsible for our weather and climate. (p. 13-17)

space satellites Instruments in orbit around earth. Weather satellites are extremely useful in understanding and predicting our weather today. (p. 6, 11-12)

telegraph — Invented by Samuel Morse in 1843. A way of transmitting messages over long distances at the speed of light. (p. 7)

thermometer — An instrument for measuring temperature. (p. 5)

Torricelli, Evangelista — An Italian scientist (1608-1647) given credit for inventing the barometer. (p. 5)

volcano — A violent eruption of molten rock and ash that breaks through the surface rock. Can cause major changes in earth's weather and climate. (p. 17)

In addition to the above, *Climate, Weather and People* also teaches about other important people, places, things and ideas. Often you can figure out the meaning of a new term by seeing how it is used in context. Make sure you know the meaning of the following (for help, check the pages listed in this Learning Power Book, as well as your dictionary and encyclopedia):

almanac (p. 4); **Aristotle** (p. 3); **axiom** (p. 3); **China** (p. 1); **constellation** (p. 4); **El Nino** (p. 16); **England** (p. 1); **France** (p. 5); **Greece** (p. 3); **Gulf Stream** (p. 16); **Japanese current** (p. 16); **kamikaze** (p. 1); **Middle Ages** (p. 4); **Milankovitch, Milutin** (p. 19-20); **Morse, Samuel** (p. 6); **Noah's Ark** (p. 4); **nuclear energy** (p. 15); **planet** (p. 11, 13-15); **pollen** (p. 9); **Renaissance** (p. 4); **Sahara Desert** (p. 9); **South Korea** (p. 1); **Spain** (p. 1-2); **tornado** (p. 21).

STUDY SUGGESTIONS ...

1. Simple weather instruments are easy to construct, including weather balloons. Set up your own weather station at school or in your own yard. Compare your measurements and predictions to those of the U.S. Weather Bureau. See book by Charles and Ruth Laird in bibliography.

2. The most watched segment of local news is the evening weather report. Most television stations conduct tours of their studios. Take one, paying special attention to the weather reporting facilities.

3. One of the least known but most interesting agencies in the Federal Government is NOAA, the National Oceanic and Atmospheric Administration. Among other responsibilities they have extensive research and management roles in national fisheries, weather and climate, oceanography, earth satellites, coastal zones and Sea Grant programs. They have major facilities in all fifty states. For information you can write: Office of Public Affairs, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 14th and E St. NW, Washington, DC 20230.

4. Meterorologists and climatologists are concerned today with the possible effects of large-scale engineering projects on our future weather and climate. A Russian plan to divert Siberian rivers for irrigation projects and the Brazilian efforts to develop the rain forest are two of the most potentially worrisome. Investigate either or both and discuss in class.

5. Two problems, acid rain and the greenhouse effect, get a great deal of publicity today. Research for yourself either or both of these subjects. Use current periodicals and suggested books in the bibliography that follows.

6. The career opportunities for professional meteorologists are much greater than generally realized. Consider how many practical economic benefits and problems the weather and climate cause. Now brainstorm how many and which private companies and government agencies might have need for people trained in meteorology.

7. If you are interested in the use of very large computers in weather and climate research write to NCAR, Scientific Computer Division, P.O. Box 3000, Boulder, CO 80307.

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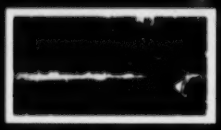

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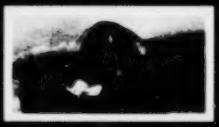

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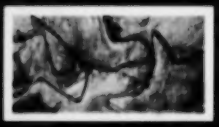

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